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I, JANENE PEISKER, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. PR 6360 for a patent by PBR AUSTRALIA PTY LTD as filed on 16 July 2001.

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WITNESS my hand this
Nineteenth day of November 2003

J.K.H.

JANENE PEISKER
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P/00/009
Regulation 3.2

AUSTRALIA
Patents Act 1990

PROVISIONAL SPECIFICATION

Invention Title: **ELECTRIC BRAKE ACTUATING ASSEMBLY AND ACTUATOR**

Applicant: **PBR AUSTRALIA PTY LTD**

The invention is described in the following statement:

ELECTRIC BRAKE ACTUATING ASSEMBLY AND ACTUATOR

The present invention relates to an electric brake actuating assembly and an electric brake actuator for actuating brakes of an automotive vehicle. It will be convenient to describe the invention as it relates to the actuation of the parking brake of a vehicle, but it is to be appreciated that the actual type of brake the invention is suitable for can be brakes other than a parking brake and could, for example, be a service brake of the drum or disc kind.

Electric brake actuators have been considered in recent times as being attractive for parking brake actuation, by facilitating removal of the need for manual parking brake actuation by the vehicle driver and by providing greater control of the braking load which is applied. As yet however, an electric parking brake assembly and actuator that is generally acceptable to the automotive industry has not been provided.

It is an object of the present invention to provide an electric parking brake actuator for use in the automobile industry and which meets with general acceptance in that industry.

In one aspect of the present invention there is provided an electric brake actuator that includes a rotatable member and electric drive means for driving said rotatable member, said rotatable member being arranged for engagement with a cable that extends into engagement with a brake assembly and said rotatable member being arranged to retract the cable in a first direction of rotation and to extend the cable in a second direction of rotation.

The cable retracting capability of an actuator of the above kind facilitates actuation of the brake assembly to apply a braking load to a wheel associated with the brake assembly. Additionally, by rotation of the rotatable member in the second direction, the cable can be extended from the retracted condition to release the braking load applied to the associated wheel.

A vehicle is normally provided with brake assemblies associated with each of the four wheels thereof. Typically, two of those assemblies (normally those associated with the rear wheels) include parking brake assemblies. Accordingly, two or more electric brake actuators according to the invention can be provided, with each being operable in relation to a separate brake assembly. Thus, in one arrangement, a pair of electric brake actuators is provided to

actuate each of the two parking brake assemblies on the rear wheels of a vehicle. Alternatively, electric brake actuators may be provided to actuate the brake assembly applied to each wheel of a four wheel vehicle. Any combination is within the scope of the invention and the brake assemblies may be service or parking brakes or a combination of both.

In this form of the invention, the rotatable member may take any suitable form, such as a drum winder or wheel. The rotatable member will include means to properly engage the cable for retraction and extension, such as by connection of a cylindrical ferrule secured to one end of the cable which can be securely fixed into a pocket or recess formed in the rotatable member. Other suitable arrangements are equally possible.

Operation of the actuator may be controlled by suitable control means, such as a computer control which determines the braking load required to be applied by the or each braking assembly and causes the rotatable member to be rotated an amount that retracts the cable sufficiently to apply that load. Where more than one electric brake actuator is employed, the control means may control them as a group, making suitable adjustments as necessary for brake lining wear, cable stretch and other characteristics that may differ between the various actuators, cables and brake assemblies.

The present invention also provides, an electric brake actuating assembly, which includes an electric brake actuator of the type according to the first aspect of the invention, that is assembled for actuation of a brake assembly which is employed in a vehicle. The actuating assembly includes a brake assembly and a cable extending from said brake assembly to said electric brake actuator. The cable is fixed to each of said brake assembly and the rotatable member of said electric actuator and the actuating assembly is operable by rotation of said rotatable member in a first direction to retract said cable and thereby actuate said brake assembly to apply a braking load, and in a second and reverse direction of rotation to extend the cable and release the braking load applied by the brake assembly.

According to a second aspect of the present invention, there is provided an electric brake actuator including a rotatable member and electric drive means for driving said rotatable member, said rotatable member being arranged for engagement with a continuous cable that extends between and in operative

engagement with a pair of brake assemblies that are operable when actuated to apply a braking load to brake a wheel associated with each respective said brake assembly, said rotatable member being arranged such that it is operable to retract said cable on each side of said rotatable member upon rotation of said rotatable member in a first direction, and to extend said cable on each side of said rotatable member upon rotation of rotatable member in a second and reverse direction.

The present invention also provides an electric brake actuating assembly, which includes an electric brake actuator according to the second aspect of the invention, which actuating assembly is operable for actuation of a pair of brake assemblies employed in a vehicle. The actuating assembly includes a cable extending between and in engagement with said brake assemblies. The electric actuator is disposed between the brake assemblies with the rotatable member thereof in engagement with the cable. The electric actuator is operable to rotate the rotatable member in a first direction in order to retract the cable extending on either side thereof, and thereby actuate each of the brake assemblies to each apply a braking load, and in a second and reverse direction of rotation, to extend the cable on either side thereof to release the braking load applied by each of the brake assemblies.

The rotatable member can take any suitable form in this second aspect of the invention and in one form, it includes a pair of spaced apart bearing surfaces, against which the cable bears and which are positioned so that the cable can extend from one bearing surface to the other and away from each of the bearing surfaces, for extension from opposite sides of the rotatable member to a respective brake assembly. The reaction forces between the respective bearing surfaces and the cable preferably are opposite, or at least include an opposite component for retracting the cable disposed on opposite sides of the rotatable member in opposite directions upon rotation of the rotatable member in the first direction.

In one form of the invention, the bearing surfaces are disposed on opposite sides of the axis of rotation of the rotatable member and preferably are spaced an equal distance away from that axis. The bearing surfaces preferably are curved and in one embodiment, they curve at a constant radius. In this arrangement, when the rotatable member is rotated, the cable on each side of

the actuator does not shift radially relative to the axis of rotation. This is an advantage, because it is simpler to control the angular rotation of a drive motor (constituting the electric drive means) to apply a given load or displacement to the cable (either in a relaxed or actuating condition) when cable displacement produced by constant radius bearing surfaces is linearly related to the angular rotation of the drive shaft of the motor. The control means employed to control the cable displacement imparted to the cable by the drive motor preferably is an encoder which is attached to the motor shaft. It is still possible to provide suitable control if the bearing surfaces are other than of constant radius, however a constant radius reduces the number of variables a control or feedback system must accommodate when analysing the signals received from the brake assembly.

The bearing surfaces are configured in order to change the direction of the cable in the section of the cable that engages the respective bearing surface. The shape or profile of the bearing surfaces is therefore limited to such shapes or profiles that do not damage the cable being employed. Thus, for example, the radius of any curved section (if any) of the bearing surfaces must be greater than that which would cause a permanent deformation, such as a kink, in the cable.

In one form of the invention, the rotatable member is formed as a circular disc with a cable groove formed in the peripheral edge of the disc and with a passage formed through the disc, preferably diametrically through the axis of the disc, which opens at either end into the base of the groove. In this form of the invention, the passage may be formed as a bore through the rotatable member, or it may be an open passage between or separating two sections or lobes of the rotatable member. In each of these forms of the passage, the bearing surface can include a shoulder of each end of the passage at the opening to the groove, on opposite sides of the passage and can additionally include the surface of the groove. In each case, the cable will extend from the passage at either end into the groove. The groove preferably has a depth about equal to twice the diameter of the cable.

In a further form of the invention, the rotatable member includes a pair of rollers rotatably mounted on spindles extending from a back plate. The rollers are disposed in the same plane or substantially the same plane and rotate

about spaced apart parallel axes. The axes are preferably disposed equidistantly on opposite sides of the axis of rotation of the back plate. Each of the rollers is formed with a groove to accommodate the cable and the cable extends between the rollers and away from the actuator to separate brake assemblies. The rollers eliminate sliding movement between the cable and the rotatable member, which may occur through uneven stretching of the cable, or from uneven loading applied to the cable. In the earlier embodiments, the cable will normally be able to slide relative to the rotatable member until such time as the friction load between the cable and the rotatable member exceeds the load causing the relative sliding. However, in this form of the invention, such frictional resistance advantageously is substantially eliminated, so that the relative movement can continue until the cable loading is even throughout the cable.

The electric drive means can take any suitable form, although an electric motor of compact form is preferred. In the preferred arrangement, the electric motor is coupled directly to the rotatable member, or is coupled indirectly through a geared arrangement. This latter arrangement is likely to be generally required, in order to reduce the rotational speed of the electric motor and to achieve the torque necessary to apply a braking load.

The cable is a continuous cable, which means it is a single length of cable which extends between the brake assemblies. The actuator according to the second aspect of the invention is arranged to cooperate with the cable between the brake assemblies, without disturbing the continuous nature of the cable. It is the case that the path of the cable will be altered through engagement with the rotatable member, but it will extend in a continuous manner through the rotatable member. The cable can be of any suitable grade, such as that which is sometimes used presently for parking brake actuation, although if the actuator is to be employed for service brake operation, then a cable of heavier grade or greater tensile strength may be necessary.

The cable preferably extends from the rotatable member in each of two substantially opposed directions. In one preferred arrangement, the cable extends substantially in the same plane between the brake assemblies, at least in the brake released condition of the brake assemblies. In the brake applied condition, there may be some planar deviation, but that is likely to be very

minor. Typically the opposite ends of the cable will be connected at the same point or location to the respective brake assemblies and it is only the point of extension from the rotatable member that will differ between the separate sections of the cable that extend to the brake assemblies. In the arrangement in which the rotatable member is of circular disc form, with a groove in the peripheral edge thereof, the cables will generally be arranged to extend from opposite sides of the disc and will be separated by a distance equal to about the base diameter of the groove. Thus the exit point of the cable sections from the rotatable member will be radially spaced and will be close to parallel.

The electric drive means may be operable to drive the rotatable member in each of the first and second directions, although it is equally appropriate for it to drive only in the first direction for cable retraction, as brake assemblies normally are biased to a brake released condition, so that the brake assembly would apply a load to the cable tending to rotate the rotatable member in the second direction in the absence of a driving force driving it in the first direction, or maintaining it against rotation in the second direction.

The attached drawings show example embodiments of the invention of the foregoing kind. The particularity of those drawings and the associated description does not supersede the generality of the preceding broad description of the invention.

Figure 1 illustrates a rear vehicle axle 10 which includes a differential 11 and a pair of wheel assemblies 12, disposed at each end of the axle 10 to which a vehicle wheel (not shown) can be mounted on the studs 13. As would be apparent to a person skilled in the art, this arrangement is a standard vehicle rear axle arrangement.

Mounted to the differential 11 is an electric brake actuator according to one aspect of the invention. The actuator 14 includes a housing 15 which includes a bracket 16 for mounting the actuator 14 to the differential 11 or the axial tube. The differential (or the axial tube) includes a platform 17 for the bracket 16 to be mounted to by any suitable means, such as by bolting.

A cable 18 extends between brake actuating levers 19 and is fixed to each by suitable links 20, which include an eye to accept and locate the ends of the levers 19. In the arrangement shown, the levers 19 are part of a parking

brake system which apply the brake shoe or shoes of a drum brake against the drum braking surface of the drum brake.

The cable 18 extends about a rotatable member 21 of the actuator 14, which is configured to define a groove 23 to accommodate the cable 18 and further to define a particular cable path such that anticlockwise rotation of the rotatable member 21 is operable to retract the cable 18 extending from each side of the rotatable member 21 and to therefore apply a pull force through the cable 18 to each of the levers 19. Displacement of the levers 19 under the influence of the pull force will actuate the brake assemblies to apply a braking load on wheels attached to each of the wheel assemblies 12. Conversely, clockwise rotation of the end member 21 will extend the cable 18 and will therefore release the pull force and result in removal of the braking load. As shown, the end member 21 includes a pair of semicircular lobes 22a and 22b (referred to collectively as "the lobes 22") which extend axially away from a base 24 and which are spaced apart to define a passage or gap therebetween. The lobes 22 are shown in more detail in Figure 2, and reference will now be made to that figure, in which like parts have the same reference numerals as in Figure 1.

Figure 2 shows the cable path and clearly shows the passage P between the lobes 22. The cable 18 as shown, follows a somewhat Z shaped path about the lobes 22 by extending from an upper end of the lobe 22b, through the passage P, to a lower end of the lobe 22a. Figure 2 further shows the outwardly facing groove 23 formed on each of the lobes 22, the groove having a depth sufficient to prevent the cable 18 from release therefrom in use.

Figure 2 further shows the bracket 16 in more detail and it is the case that the bracket 16 provides flexibility in the direction X, by way of flexible mounting plates 25. The mounting plates 25 allow for movement in the direction X, but are substantially inflexible to rotation about the axis Y. Flexibility is desirable in the Figure 2 embodiment, in relation to the action of cable equalisation which is referred to later herein.

Figure 2 also shows the mounting plate 26 and a pair of mounting bolts 27 for mounting the actuator 14 to the platform 17. An electrical lead 28 extends from the rear of the actuator 14.

Figure 3 is an end view of Figure 2 showing the lobes 22 and in broken line, the base of the groove 23 formed in the lobes 22 that accommodates the cable 18. The depth D of the groove is shown to be in excess of twice the diameter of the cable 18. The path of the cable 18 is also shown in this figure. Figure 3 illustrates the bearing surfaces which are the surfaces of engagement between the lobes 22, the groove 23 and the cable 18. The bearing surface is constituted by portions of the passage and groove surfaces and in the arrangement shown, as the rotatable member 21 rotates in an anticlockwise manner, the bearing surface will increase along the groove 23 provided on each of the lobes 22.

As shown in Figure 3, the cable 18 extends from one bearing surface to the other, and away from each of the bearing surfaces for connection to separate brake assemblies.

Figure 4 is a cross-sectional view of the actuator 14, through the axis Y of Figure 2. As shown, the actuator 14 includes a housing 15 and a pair of lobes 22a and 22b. Each of the lobes 22 defines a groove 23 to accommodate the cable 18. The rotatable member 21 includes a base 24 and the lobes 22 are formed integrally with the base 24 and project axially outwardly therefrom.

The rotatable member 21 is fixed to an annular gear 29 by a plurality of threaded fasteners 30, only one of which is shown in Figure 4. Three such fasteners would be employed disposed at 120° to each other.

Gear cluster 31 and 31a is disposed in meshing engagement with each of the annular gear 29 and the casing or outer ring gear 32. The gear cluster 31, 31a is mounted on an eccentric shaft 33 which is driven by an electric motor 34 (of which only the position is shown) through a coupling 35. The motor shaft 36 is supported in front and rear bearings 37 and 38. This arrangement can provide high reduction ratios.

Dust covers 39 and 40 are fitted at opposite ends of the actuator 14.

A manual override 41, 42, concealed by the respective dust covers 39 and 40 is shown provided at each end of the actuator 14, although in practice, only one of these is required. The overrides 41 and 42 preferably are key operable, suitable say to receive an appropriate Allen key. The manual overrides are provide in the event that the actuator fails electrically and it is necessary to rotate the end member 21 to apply or release the parking brake

manually, or to release the cable 18 from the groove 23. The manual override 41 is operable to rotate the end member 21 by rotating the eccentric shaft 33, while the manual override 42 is operable to rotate the motor shaft 36.

The actuator 14 further includes a bearing 43 between the outer surface of the annular gear 29 and the inner surface of the outer ring gear 32 and a further bearing (not shown) between the eccentric shaft 33 and the annular gear 29. There are also counterweights applied to the eccentric shaft 33 which are not shown, but which are applied to minimise or eliminate out of balance rotation and to so improve smoothness of operation. A seal 44 is disposed between the annular gear 29 and the outer ring gear 32 to prevent the entry of foreign matter.

The arrangement shown in Figures 1 to 4 is operable such that rotation of the end member 21 in an anti-clockwise manner will cause a pull force to be applied in opposite directions to the cable 18, on either side of the actuator 14. That pull force will act on each of the levers 19 to apply the parking brakes disposed respectively in the wheel assemblies 12. Rotation of the end member 21 in a clockwise direction will release the applied pull force for release of the parking brakes.

The arrangement shown in Figures 1 to 4 provides several advantages. One of the advantages is in the ease of assembly that the configuration of the end member 21 affords. The end member 21 permits a single or continuous cable to be employed and assembly is facilitated by disposing the end member 21 so that the passage P extends lengthwise substantially horizontally. Disposed in that manner, the cable 18 can be joined at either end to the levers 19 and then inserted into the passage P. Thereafter, the electric motor 34 can be activated to rotate the end member 21 anticlockwise, so that the cable 18 is captured in the groove 23 under tension.

The alternative method of assembly can comprise attaching one end of the cable 18 to one of the levers 19, threading the cable into the passage P, and thereafter attaching the other end of the cable to the other lever. Rotation of the end member 21 can then be initiated as necessary to tension the cable ready for use. The actual method of assembly can be varied but still maintain ease of assembly.

A further advantage in the arrangement shown in Figures 1 to 4 is that it can permit some slipping movement of the cable relative to the lobes 22 and through the passage P, to provide for equalisation of the load applied through the cable on either side of the actuator 14. Unequal loading may occur through stretching of the cable 18 on only one side of the actuator 14 or by unequal stretching. Alternatively, there can be unequal loading if the parking brakes fitted to the respective wheel assemblies 12 require different amounts of lever 19 movement to properly engage. Thus, by permitting the cable to slip relative to the rotatable member 21, the loading applied in either side of the rotatable member can be equalised and there can be some certainty that the pull force applied to the levers 19 is equal.

Equalisation may also provide benefits in the event of a greater wearing or compression of the brake lining of one of the parking brake assemblies compared to the other. In this case, the more worn or compressed lining will require greater travel to engage the drum braking surface than the other lining. Accordingly, the lever 19 operating with the worn or compressed lining will require a longer pull than the other lever. This can be achieved by slippage of the cable 18 when the less worn or compressed lining initially engages the drum braking surface, with the slippage continuing until the worn or compressed lining also engages the drum braking surface. The arrangement therefore is self-equalising. This is particularly advantageous when the parking brake is used for the first time, because it can set the cable properly simply by rotation of the rotatable member to tension the cable. The cable will slip relative to the rotatable member 21 to bed in correctly. This is an advantage with a new vehicle, as well as older vehicles that may undergo brake maintenance, such as brake shoe replacement.

Any cable slippage will discontinue when an equal force is applied on either side of the rotatable member, or when an equal resistance from each lever 19 is met through the cable 18. Also slippage will discontinue if the frictional load between the cable and the groove exceeds the difference between the loads applied to the cable on either side of the actuator. In that case, the flexibility of the bracket 16 by the flexible mounting plates 25 (see Figure 2) then permits a shift in the position of the actuator in either of the

directions of cable extension, depending in which direction the greater load applies.

Figure 5 shows a further embodiment of the invention which employs the actuator 14 shown in Figures 1 to 4. Accordingly, like parts have been given the same reference numeral, plus 100. In the Figure 5 embodiment, the cable 118 extends from either side of the actuator 114 and into a conduit 100. Each of the conduits 100 are fixed at either end to fixed brackets. Each of the brackets 101 is fixed to a vehicle mount (not shown) that is at the same planar position as the base 126 of the actuator bracket 116. Thus, each of the points A, B and C shown in Figure 5 are the same ground and the cable 118 extending between points B and C is substantially coplanar.

The cable 118 enters the conduits 100 at each of the brackets 101 through an opening formed therein and extends through the conduit to exit through openings formed in the brackets 102, disposed at the other end of the conduits 100. As shown, the cable 118 extends to the parking brake levers 119 and engages those levers through links 120.

The Figure 5 arrangement is an example of how the present invention can be modified to suit different parking brake assemblies. The Figure 1 arrangement includes levers 19 that are displaced by the cable 18 toward the actuator 14, while in Figure 5, the levers 119 are displaced at 90° to the Figure 1 displacement. Thus, re-routing of the cable 118 through conduit 100 permits the invention to be employed regardless of the required direction of lever displacement.

The Figure 1 embodiment employs a cable which is completely "bare", while the cable shown in Figure 5 is partly bare and partly conduited. The completely bare arrangement is preferred, in terms of weight, efficiency and cost, although the cable layout will dictate whether full or part conduit is required. A bare cable is suitable if the cable path has a direct line of sight between the lever 19 and the rotatable member 21. If the line of sight is indirect, then conduiting is generally required.

Figure 6 shows an alternative embodiment of an rotatable member 221 suitable for use in the present invention. The rotatable member 221 can be employed in place of the end member 21 of Figures 1 to 5.

The rotatable member 221 is formed as a circular disc defining front and rear plates 222, 223 and a groove 224. In this respect, the rotatable member 221 is formed like a pulley having a U-shaped groove 223. An opening 225 is formed to extend through the centre of the member 221, to allow passage of the cable 218 and the cable link 220. Figure 7 illustrates this arrangement whereby the rotatable member 221 is shown in plan view with the groove 223 and the opening 225 shown in broken line extending between diametrically opposed base portions of the groove 223.

The rotatable member 221 is operable in the same manner as the end member 21, although it provides added security against the cable 218 being dislodged from the groove 223. It also is potentially more easily manufactured. The rotatable member 221 does require modified cable assembly, in that the cable 218 must be threaded through the opening 225, so that one of the possible assembly methods for the cable 18 and the end member 21, that of connecting each end of the cable 18 to the levers 19 before applying the cable to the end member 21, is not available with the rotatable member 221.

A particular advantage of the invention, available with either of the end members 21 or 221, is that by virtue of a substantially constant groove radius R (see Figure 3), a shift in the vertical position of the cables 18 and 218 (represented by VP in Figure 3) upon rotation of the end members 21 and 221, can be eliminated, or at least substantially eliminated. This is highly advantageous for the computer feedback systems employed in modern vehicles, which will control the amount of rotation of the end member 21 to apply or release the required braking force. If there is movement in the vertical position of the cable during brake actuation, so called 3D movement, then the analysis required to be carried out by the computer becomes more complicated and therefore more prone to error. Also, as discussed earlier, the constant groove radius R advantageously means that a linear relationship exists between cable travel and the angular rotation of the electric drive motor shaft.

A further embodiment of the invention is shown in Figure 8 and this shows an actuator 314 including a motor housing 315 and a rigid bracket 316 for mounting the actuator 314 to the differential or axial tube, or other suitable component of a vehicle. The actuator 314 includes a rotatable member 321 which is driven by an electric motor mounted within the housing 315. A geared

drive arrangement of the kind shown in Figure 4 may be employed for this purpose. The rotatable member 321 includes rollers 330 and 331. The rollers 330, 331 are each formed like pulleys, so as to define a central groove 332 in the edge periphery thereof. The rollers 330, 331 are each rotatably mounted to the rotatable member 321 on central spindles or axles 333.

A cable 318 extends from opposite sides of the actuator 314 and extends as shown about the upper external periphery of the roller 330, downwardly and about the lower external periphery of the roller 331.

The operation of the actuator 314 is similar to the embodiments described earlier, in that by rotation of the rotatable member 321 in a clockwise direction, the cable 318 will be retracted on each side of the actuator 314. Conversely, rotation of the rotatable member 321 in an anticlockwise direction will extend the cable 318 on each side of the actuator 314. As described in relation to the earlier embodiment, this retracting and extending cable movement can be employed in a brake actuating assembly to apply and release vehicle brakes. However, the actuator 314 provides advantages in relation to cable equalisation compared to the earlier described embodiments. In contrast to the earlier embodiment, the actuator 314 permits equalisation without the need for a flexible bracket 16 of the kind described earlier in relation to Figure 2. In the Figure 8 embodiment, the cable 318 does not meet the frictional resistance that the cable 18 experiences during relative sliding movement in the grooves 23 of the lobes 22, because the cable 318 does not slide relative to the rollers 330, 331, but instead, the movement is relatively non-frictional rolling movement. Thus, the actuator 314 permits substantially complete equalisation while employing a rigid mounting bracket.

The invention described herein is susceptible to variations, modifications and/or additions other than those specifically described and it is to be understood that the invention includes all such variations, modifications and/or additions which fall within the spirit and scope of the above description.

DATED: 16 July 2001
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David B Fitzpatrick

Fig 1

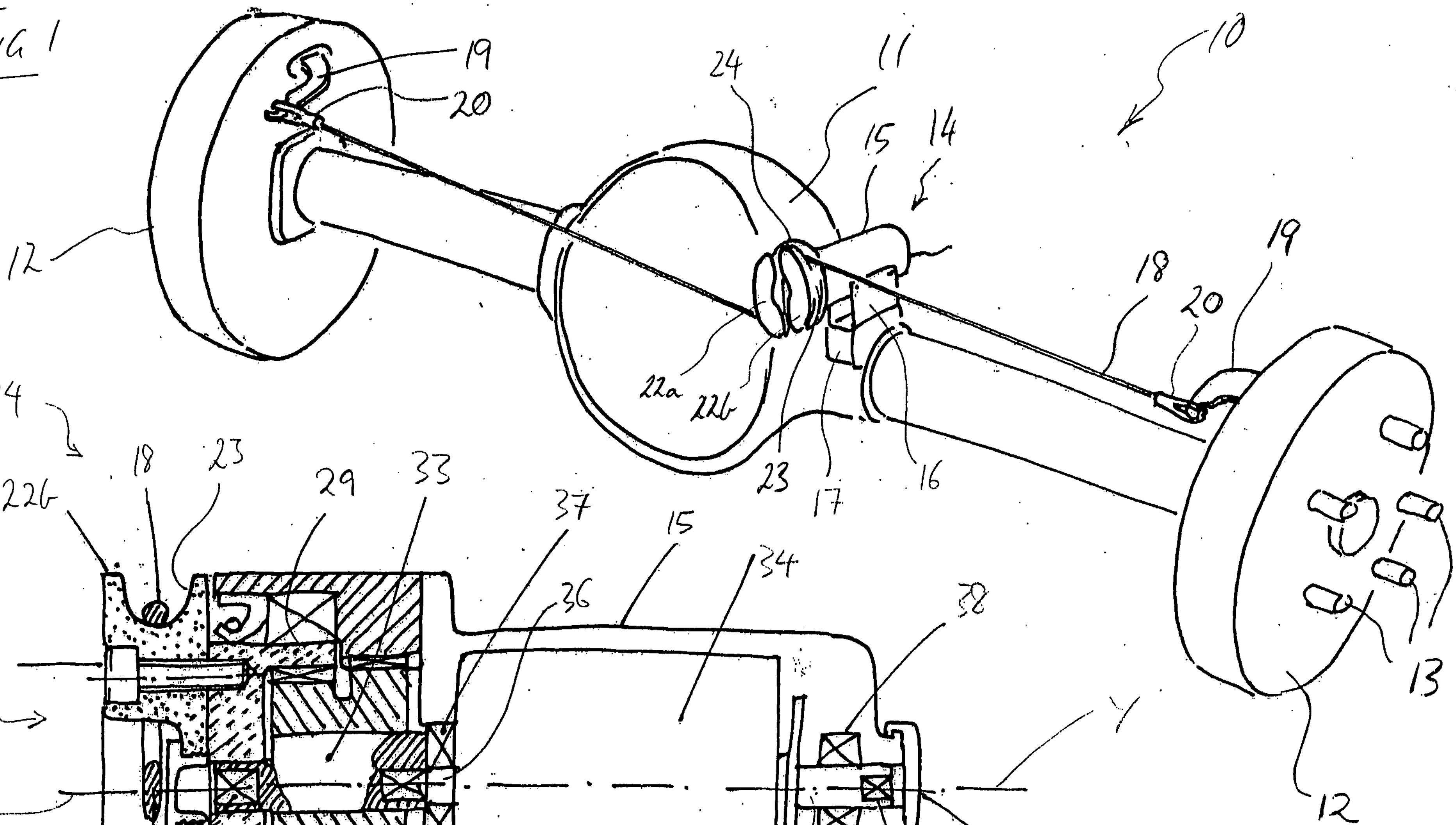
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Fig 4

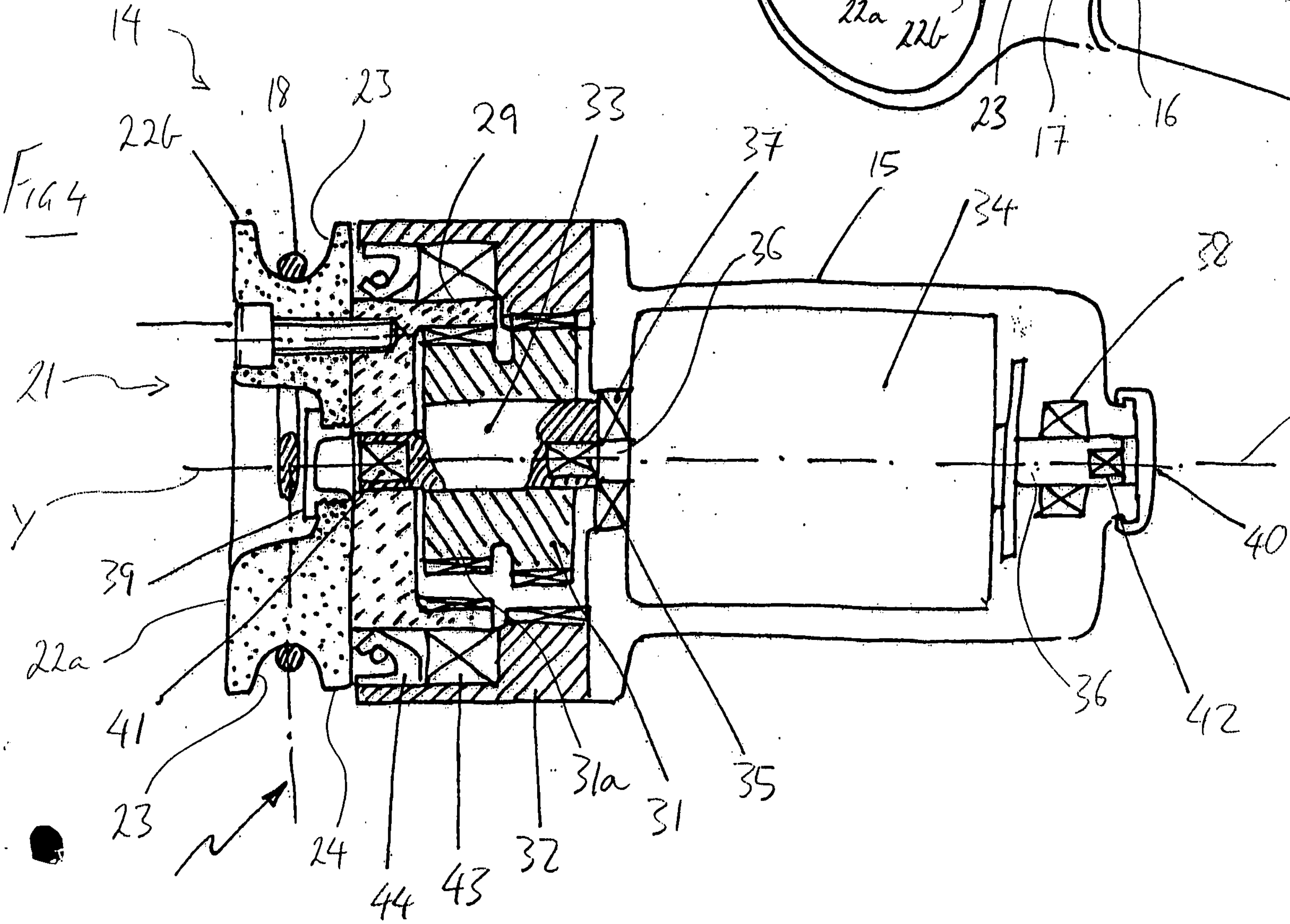
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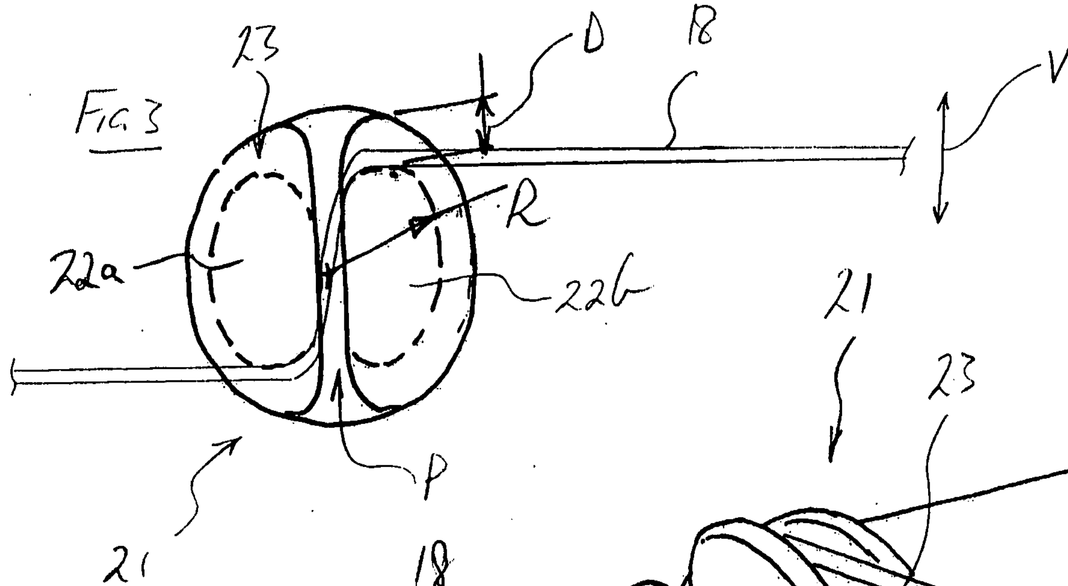
Fig 3



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VP
R
22a
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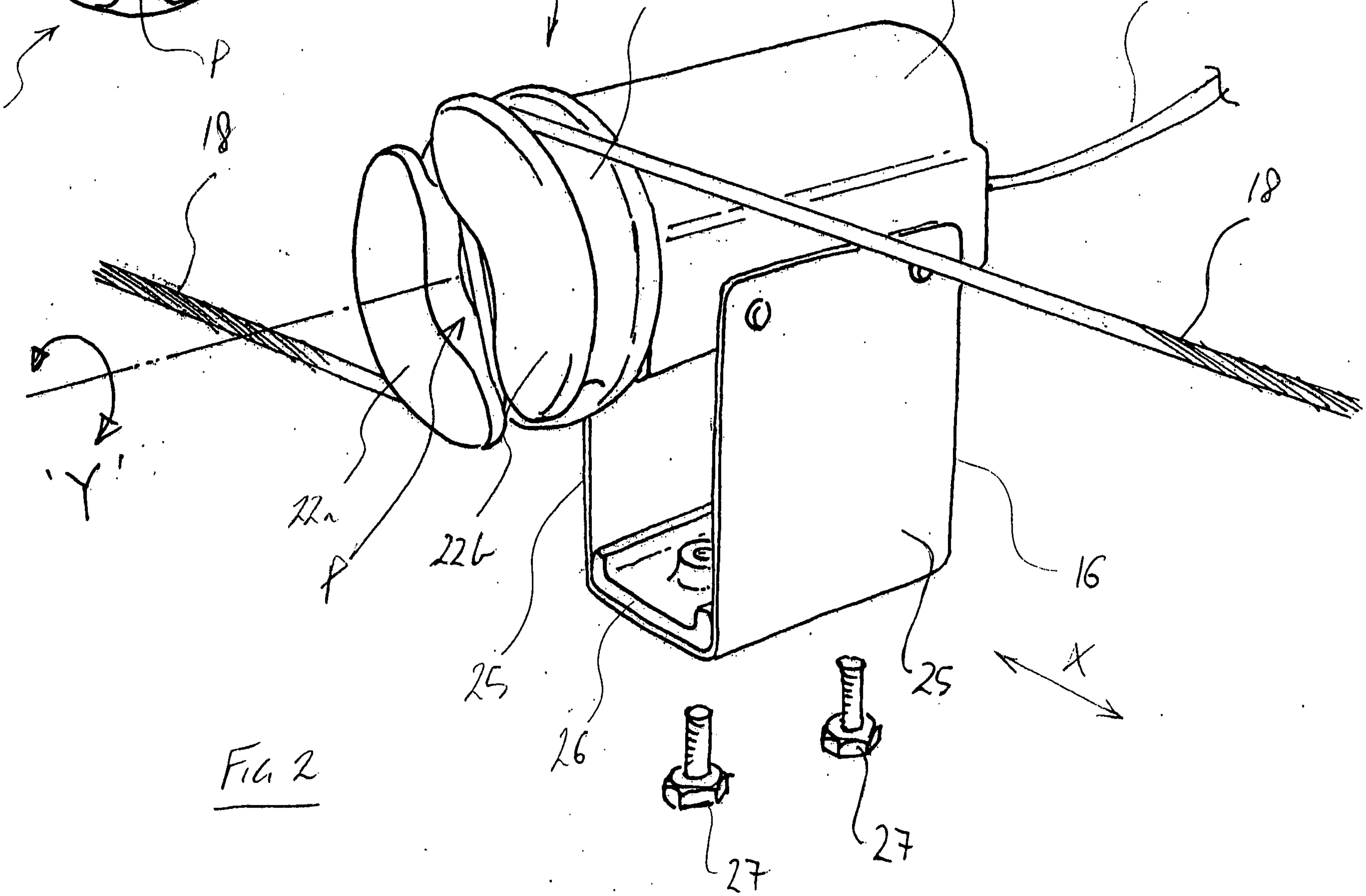
P
21



14
21
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'Y'
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P
22b
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26
16
25
X
27
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Fig 2

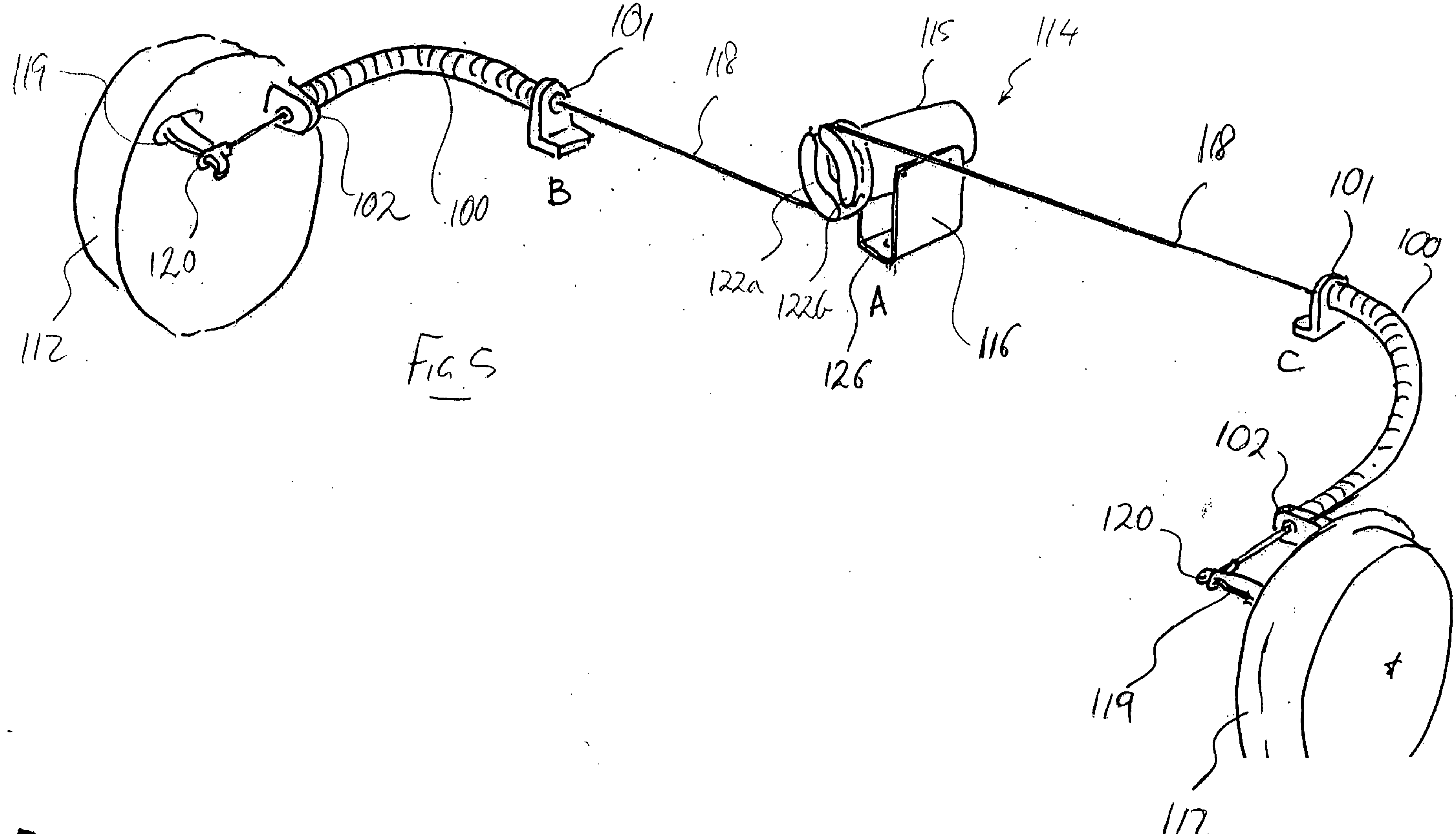
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FIG 5

FIG 6

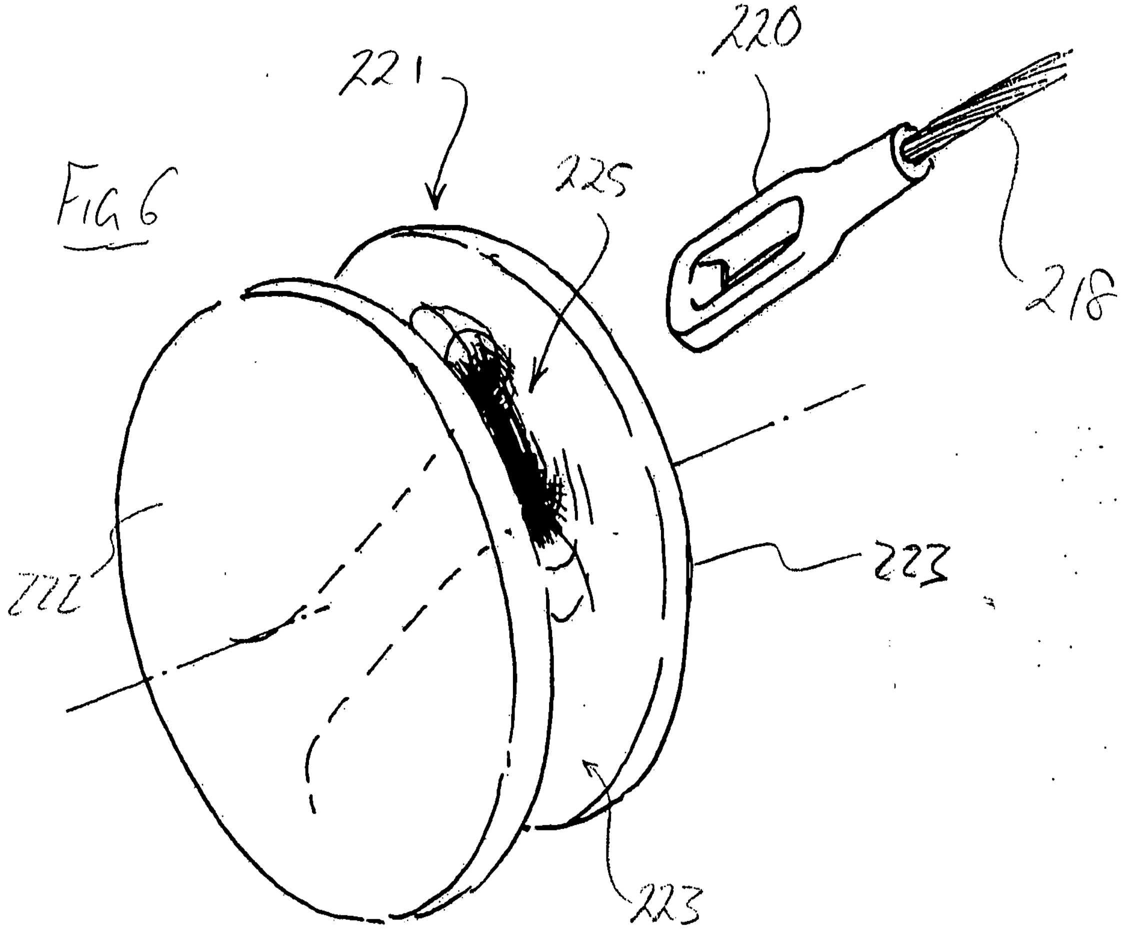

FIG 7

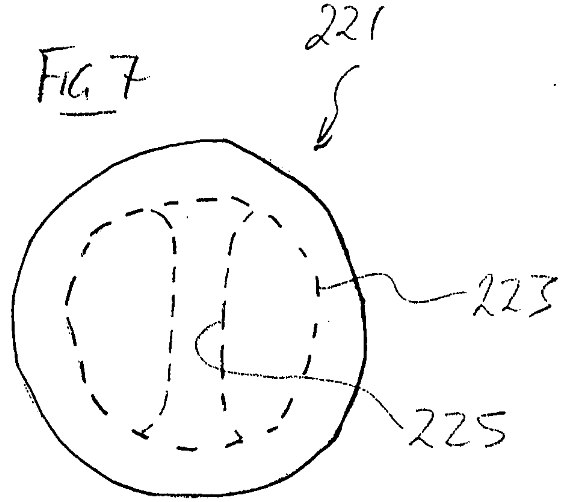

FIG 8